Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Supporting Information

Regulating anti-thermal quenching to zero thermal quenching for highly efficient blue-emitting Eu^{2+}-doped K-beta-alumina phosphors

Yuhang Kuang, [a] Yunjia Li, [a] Borui Chen, [a] Shujuan Zhao, [a] Mengfang Chen, [a] Shixun Lian, [a] Jilin Zhang *[a]

[a] Key Laboratory of Light Energy Conversion Materials of Hunan Province College, Key Laboratory of Chemical Biology and Traditional Chinese Medicine Research (Ministry of Education of China), Hunan Normal University, Changsha 410081, China

*Email: chemzhangjl@hunnu.edu.cn

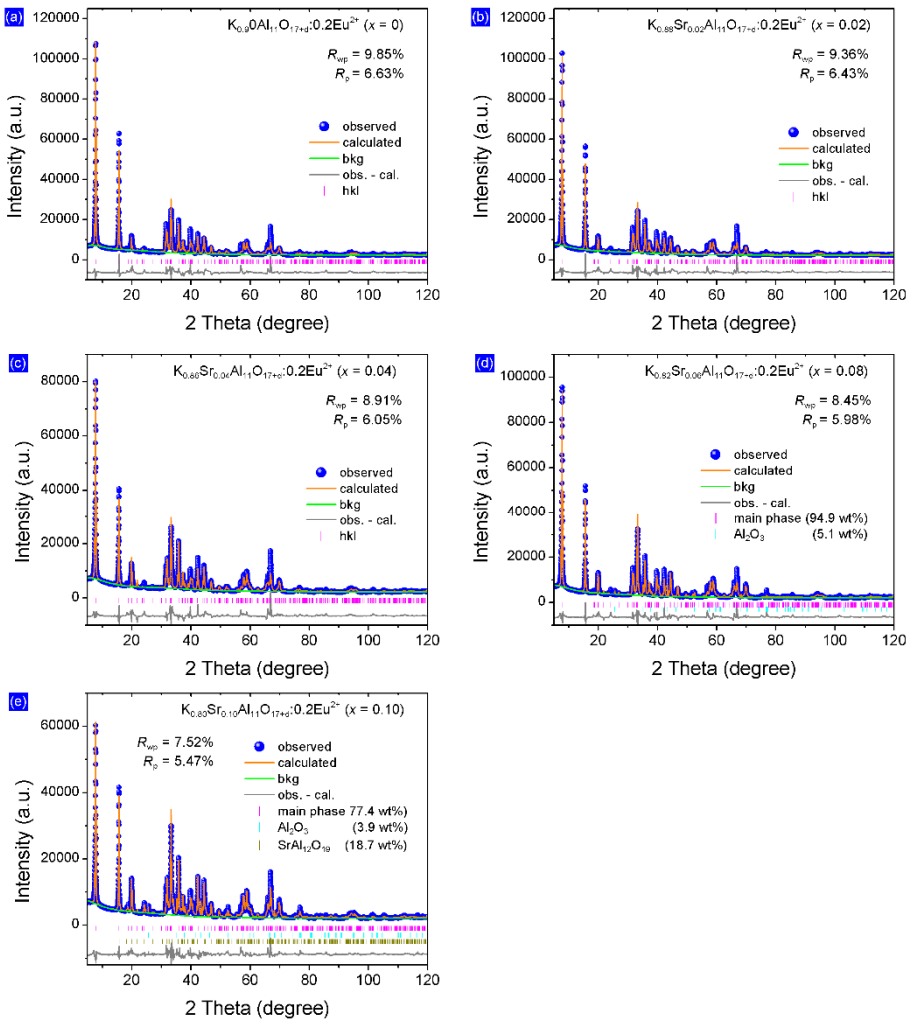

Figure S1. Rietveld refinement results for $K_{0.90-x}Sr_xAl_{11}O_{17+d}$:0.2$Eu^{2+}$. (a) x = 0, (b) x = 0.02, (c) x = 0.04, (d) x = 0.08, (e) x = 0.10.

Table S1. Cell parameters of $K_{0.90-x}Sr_xAl_{11}O_{17+d}:0.2Eu^{2+}$ (x = 0.06)

Atom	Wyck.	Site	x / Å	y / Å	z / Å	S.O.F	U_{iso} / Å^2
K1	6h	mm2	0.66732	0.33463	1/4	0.222	0.0098
Sr1	6h	mm2	0.66732	0.33463	1/4	0.01	0.0098
Eu1	6h	mm2	0.66732	0.33463	1/4	0.0444	0.0098
K2	6h	mm2	0.88396	0.76791	1/4	0.058	0.0098
Sr2	6h	mm2	0.88396	0.76791	1/4	0.01	0.0098
Eu2	6h	mm2	0.88396	0.76791	1/4	0.0222	0.0098
Al1	12k	m	0.83143	0.66287	0.10856	0.9837	0.0065
Al2	4f	3m	1/3	2/3	0.02840	1	0.0111
Al3	4f	3m	1/3	2/3	0.17066	0.9294	0.0024
Al4	2a	-3m	0	0	0	1	0.0211
O1	12k	m	0.15747	0.31495	0.05328	1	0.0064
O2	12k	m	0.50196	0.00393	0.14264	1	0.0122
O3	4f	3m	2/3	1/3	0.04890	0.9354	0.0127
O4	4e	3m	0	0	0.14287	1	0.0322
O5	6h	mm2	0.30183	0.60366	1/4	0.333	0.0489

Table S2. Cell parameters of $K_{0.90-x}Sr_xAl_{11}O_{17+d}:0.2Eu^{2+}$

	a / Å	c / Å	V / Å^3
x = 0	5.597(1)	22.685(1)	615.45(4)
x = 0.02	5.600(1)	22.690(1)	616.26(4)
x = 0.04	5.608(1)	22.718(1)	618.65(4)
x = 0.06	5.603(1)	22.696(1)	616.99(3)
x = 0.08	5.605(1)	22.706(1)	617.74(3)
x = 0.10	5.598(1)	22.680(1)	615.55(4)

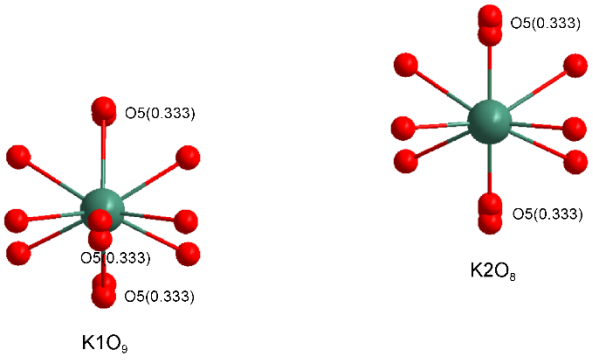

Figure S2. $K1O_9$ and $K2O_8$ polyhedrons.

Table S3. K-O bond lengths (Å) for $K_{0.90-x}Sr_xAl_{11}O_{17+d}:0.2Eu^{2+}$

	K1-O2(×6)	K1-O5(×3)	*D* of K1	K2-O2(×4)	K2-O4(×2)	K2-O5(×2)
x = 0	×4: 2.862(1)	×2: 2.984(1)	0.03277	3.083(1)	2.688(1)	2.557(1)
	×2: 3.020(1)	×1: 3.288(1)				
x = 0.02	×4: 2.874(1)	×2: 3.112(1)	0.03753	3.093(1)	2.677(1)	2.776(1)
	×2: 2.919(1)	×1: 3.196(1)				
x = 0.04	×4: 2.946(1)	×2: 3.125(1)	0.02696	3.140(1)	2.642(1)	2.660(1)
	×2: 2.959(1)	×1: 3.149(1)				
x = 0.06	×4: 2.912(1)	×2: 3.090(1)	0.02680	3.093(1)	2.680(1)	2.559(1)
	×2: 2.918(1)	×1: 3.100(1)				
x = 0.08	×4: 2.837(1)	×1: 3.025(1)	0.04111	3.075(1)	2.637(1)	2.648(1)
	×2: 3.008(1)	×1: 3.047(1)				
		×1: 3.335(1)				
x = 0.10	×4: 2.906(6)	×1: 3.052(1)	0.2322	3.070(7)	2.627(10)	2.546(1)
	×2: 2.971(8)	×1: 3.040(1)				
		×1: 3.158(1)				

The polyhedral distortion index (*D*) can be calculated by the following equation,[1]

$$D = \frac{1}{n}\sum_{i=1}^{n}\frac{|l_i - l_{\mathrm{av}}|}{l_{\mathrm{av}}}$$

where l_i and l_{av} are the single and average bond length for the central atom and coordinating atom(s), respectively.

Table S4. Thickness (Å) of the spinel blocks and K layers*

	Spinel blocks	K layers
x = 0	6.4833	4.8591
x = 0.02	6.4675	4.8774
x = 0.04	6.4841	4.8748
x = 0.06	6.4850	4.8628
x = 0.08	6.5422	4.8111
x = 0.10	6.6136	4.7266

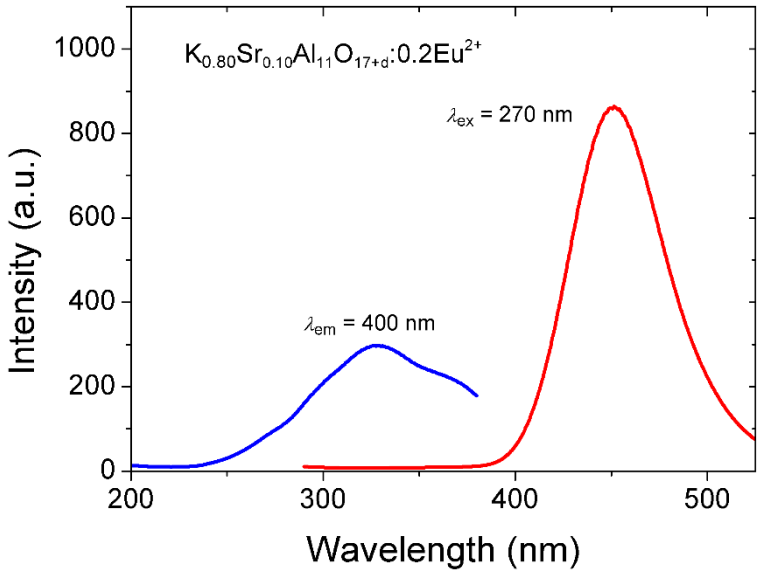

Figure S3. PL (λ_{ex} = 270 nm) and PLE spectra (λ_{em} = 400 nm) of $K_{0.80}Sr_{0.10}Al_{11}O_{17+d}$:0.2$Eu^{2+}$.

The $SrAl_{12}O_{19}$:Eu^{2+} exhibited a PL band at around 400 nm under excitation at 272 nm, according to published literatures.[2,3] However, $K_{0.80}Sr_{0.10}Al_{11}O_{17+d}$:0.2$Eu^{2+}$ has no PL and PLE spectra that are similar to $SrAl_{12}O_{19}$:Eu^{2+}. This phenomenon indicates that the formation of a small amount of $SrAl_{12}O_{19}$:Eu^{2+} does not influence the PL profile of $K_{0.90-x}Sr_xAl_{11}O_{17+d}$:0.2$Eu^{2+}$.

[1] X. Zhang, M.-H. Fang, Y.-T. Tsai, A. Lazarowska, S. Mahlik, T. Lesniewski, M. Grinberg, W. K. Pang, F. Pan, C. Liang, W. Zhou, J. Wang, J.-F. Lee, B.-M. Cheng, T.-L. Hung, Y.-Y. Chen, R.-S. Liu, *Chem. Mater.*, 2017, **29**, 6781-6792

[2] R. Zhong, J. Zhang, X. Zhang, S. Lu and X.-j. Wang, *Nanotechnology*, 2007, **18**, 445707.

[3] R. Zhong, J. Zhang, X. Zhang, S. Lu, X. Ren and X.-j. Wang, *J. Phys. D: Appl. Phys*., 2018, **41**, 065104.